

THE ART OF WRITING SCIENTIFIC REPORTS

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## THE ART OF WRITING SCIENTIFIC REPORTS

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The report is the medium by which the results of investigation and research are conveyed to those people who are, or can be, interested in the subject, and like all mediums, to be efficient, it should carry its message as quickly and as smoothly as possible. It should not only transmit the actual data obtained, the cold facts and figures, but it should also carry to the reader a feeling of confidence in the work accomplished, and should so coordinate the results with similar work, that their true significance can be realized. A well-written report forms a reasonable and coherent addition to the world's knowledge. As the purpose of the report is to transmit as smoothly and easily as possible, certain facts and ideas, to the average person likely to read it, it must, then, be written in a full and simple enough manner to be comprehended by the least tutored, and still not be boring to the most learned, of the group who may be considered as interested readers. This demands clearness of expression, a concise though complete treatment, and an interesting style of writing.

Perhaps the most important quality a report can have is interest, for if it is not interesting it will not be read and if it is not read, it has failed in its purpose. Of course, some discoveries are of such great importance that, even though imparted in the most unpalatable form, they are widely and eagerly read, but these are only occasional instances, for the average piece of research is not of enough value for many to take the trouble to read carefully a muddled and dry report of the work. On the other hand, many will read a clear and interesting report even on subjects to which they have before given little thought. It is easy to tell an interesting report from an uninteresting one, but it is more difficult to determine what features distinguish a good report from a poor one. The most important feature in the creation of interest is probably

the style of writing. Style is a rather broad and indefinite term, and various readers will not agree on what constitutes a good style, but writing that leaves the reader's mind in such a condition that it can uninterruptedly and contentedly follow the meaning of the report, without being conscious of the words, is what I should consider a good style. Like every other piece of writing the report should have a definite object. There should be no digression from it, and there should be no doubt in the reader's mind what that object is. Awkward and incoherent sentences, abrupt beginnings and endings of ideas, and incomplete expression all tend to interrupt the smooth flow of meaning from the paper to the mind. There are, however, certain cases, when, for the sake of emphasis, it is desirable to bring out a statement strongly, by an abrupt breaking of the sequence of ideas, but this method, to be of value should not be frequently used. Besides the rather obvious requisites for good style, there is that rather indefinite quality that expresses the individuality of the writer. Some writers have the happy faculty of making anything they touch upon interesting, and, although it is impossible to explain just why this should be, I believe that the author must be really interested in his subject before he can interest his readers.

To have a wide influence, a report must inspire confidence. When a statement is made, it must be based on something tangible, so that there will be no feeling of doubt or skepticism as to its derivation. I do not mean that no statement should be made unless it is an indisputable fact, for that would greatly, perhaps entirely, limit them, but enough information should be given on the methods and apparatus used in experimentation, to allow the reader to accurately judge of their validity. For example, no one would have any confidence in a curve plotted from experimental data if the actual points observed were not placed on the curve, or at least a discussion of their accuracy included. Before any serious experimental work is done, the precision of the observations should be determined, so that it can be definitely known just what confidence can be placed on the results. Perhaps the surest way of winning the confidence of the reader is to record the data from two runs taken under identical conditions, the check run serving to indicate what may be expected in the way of precision in the remaining data. When, as is often the case, certain conditions not under the control of the experimenter, as for

example the weather, give a considerable degree of uncertainty to his results, it should be completely explained, for the least hint of a lack of frankness will defeat the purpose of that report and will leave any other report by the same writer open to suspicion.

It is, of course, unnecessary to emphasize the importance of absolute integrity in any scientific writing, and yet it is so easy for even the best intentioned experimenter to be unduly influenced by some preconceived idea, that it may not be out of place to take up this point. It is very easy in many reports, without deliberately altering the data obtained, to considerably change the results by omitting facts that do not substantiate the theory that is trying to be proved. There are cases when undoubtedly this is intentionally done, but on the whole the writer is not conscious of any dishonesty, but simply has evolved a certain theory, and can not conceive of any results being correct that do not fit in with that theory. It is the most difficult thing in the world to approach a subject with an open mind and draw conclusions with entire impartiality, in fact the human mind is not constituted that way, and only with practise and care can we approach that ideal condition. We are always trying to twist the facts, wherever they have the least flexibility, to fit together into a reasonable whole, and it takes the greatest care not to twist them beyond the permissible limits. It is always better to omit a whole set of data, part of which is in disagreement with the rest, than to assume one portion as correct, and find in further experiments, that the wrong portion had been published, an embarrassment that I am afraid a good many investigators have experienced.

In order that the reader may understand the report as quickly and with as little effort as possible, it should be written clearly. Clearness depends on several factors, the most important of which is to write exactly what is meant. It is very difficult for a person who has studied a certain subject thoroughly, to put himself in the reader's place, and write with enough completeness to cover all uncertain points. Facts which seem to him self evident, are unknown to the reader, so that it requires the greatest care to cover all uncertainties that may arise in his mind. It is often the case that a person can write more clearly on a subject which he is still struggling with, than after he has

completely mastered it. On the other hand, it is equally injurious to clearness to write too much. Long introductions, lengthy descriptions and the carrying of deductions beyond the limit set by the completeness and accuracy of the data, all tend to obscure the meaning.

One of the most common faults in reports is profuseness, some writers having developed the art of expressing a one sentence idea into a whole paragraph, to a high degree. Such spreading tires the reader so that he often does not take the trouble to search a whole page to find the few sentences of value. Writing reports with the idea of covering as many pages as possible is an excellent way of limiting its readers to those whose time is of little value.

As in any kind of writing, clearness is dependent on the three essentials, unity, coherence and emphasis. A report should not cover too much territory or no one will take the time to search for the particular part they want, and any digression takes the mind away from the main thought. The writer should not rush into his subject at full speed neither should he take an unduly long time to get started, or the reader's interest will be lost, but he should lead up to his subject naturally and directly in a few sentences or a paragraph, stating the reasons for undertaking the report. It has been the practise with some writers to summarize briefly their report near the beginning. This enables one to tell at a glance just what the report is about, and except for very brief papers, should always be done. The material in the body of the report should be arranged in a logical manner, description of apparatus, methods of testing, results and conclusions. The end of a report remains longest in the reader's mind, so that there should be placed the statements which it is desired to give the most emphasis. It is good practise in long reports to place subtitles before each paragraph or group of paragraphs so that any particular portion can be found at a glance. After a report has been written, it often happens that the author has some further additions to make; and instead of rewriting the report, the additional material is usually added in the form of a supplement or appendix. This procedure somewhat destroys the literary quality of the report, but is sometimes necessary. It is, however, a great help to clearness to place in an appendix any mathematical proofs and computations that are not absolutely necessary for the understanding of the report.

Photographs and other illustrations are of the greatest value; first to make the report interesting, and second to make it clear and concise. A report well illustrated, especially with photographs will be much more widely read than one without illustrations. A picture creates interest, because it stimulates the imagination and because it shows under just what conditions the experimental work was conducted, giving a more personal note to the whole report. Further than this, a good illustration is often the quickest way to convey an idea, and every one likes to absorb his knowledge with the least effort. It often happens that a good illustration will do the work of a whole page of description and in about one tenth of the reader's time. For the same reason results should be shown wherever possible in graphical form, a method that is almost universally used. When the results can be plotted as precisely as the data permit, there is no need of giving the data in tabular form. Each illustration should have a title and a short explanation, so that the reader can tell at once what he is looking at without the necessity of searching through the text, and it is also advisable to place the illustrations as closely as possible to the portion of the text to which they refer.

There are many writers, some good and some poor, who convey an air of self-importance in their works which does much to detract from their popularity. It is right and natural that a man should be proud of a good piece of work that he has accomplished, but to constantly remind the reader of it, is certainly poor taste. A good report may be safely allowed to rest on its own merits, and will receive its recognition much quicker if accompanied by a degree of modesty. Again some writers make themselves unpopular by not giving credit in the report to the men who have been working under him during its preparation. No one ever gained anything in the long run by withholding proper credit, and I am sure they have never lost by showing the value of their assistants' services. Another bad habit some writers have is to depreciate the previous work of others along their line, and claim more originality for their work than the facts will permit. Such procedure leads only to unpopularity, and the public is never fooled for long. It is well, then, to write in a modest and straightforward manner, and to give others their due amount of credit.

There is always the problem of bringing together the so-called practical and theoretical men. The mathematician rather scorns the engineer who is not versed in higher mathematics, and the engineer, in turn, often regards the mathematician's work as a waste of white paper. It is strange how distinctly separated are the two classes and how few men really sympathize with both. It can be more or less truly said that the engineer's definition of theoretical, is something he can not understand, and the mathematician's definition of practical is something he can not do. As the mathematician is chiefly known through his writings, it is important that he present his ideas in a form that will do the greatest amount of good; that is, his reports should be read not only by his fellow mathematicians, but also by the men who can make use of them in engineering and industrial development.

Even though a man has the training and the ability to handle higher mathematics, unless he has the time to frequently use it, it will soon become difficult for him to follow carefully the work of others. Also the engineer is too busy to spend much time on theory, even if he were able to handle it easily. There are, of course, a few men who are practical engineers and at the same time great mathematicians, but such men are few, as the average engineer feels that he can better obtain a mathematician to do his work for him than to spend the time himself.

For these reasons, the average scientific reports should not, as is too often the case, be so filled with complex mathematical discussions that real results and conclusions are so completely obscured that the engineer can not take the time to find them. In order to bring the physical meaning out clearly, plots should be frequently used. For example a complex equation representing harmonic motion would mean very little to most people, but a curve of the motion against time would show at a glance just what was meant.

There are a great many reports whose influence would be tremendously increased by the reduction of the number of integral signs and an increase in the number of illustrations. Most people will naturally skip quickly over any mathematics that occurs in a report in the same way that they would dodge a patch of mud in the street, and if the mud becomes too thick they will take



some other way, and yet these are the people who could make the greatest use of the material contained in the report. On the other hand every one will look at a picture, especially a photograph, even though they are only remotely interested in the subject, and often their curiosity will be aroused enough so that they will completely read the report. It is much easier to write a description than to make a drawing or take a photograph, but when it is considered that each person reading the report will be saved several minutes by doing the latter, there is no question of its value. In the same way it is easier to write an abstract equation than it is to give a clear physical conception of the relation, but the latter will save most readers much time and trouble.

There are of course reports which consist primarily of pure mathematics, and are of use chiefly to the mathematician, so that the writer can assume that all of his readers will have such an understanding of allied work, that it will be unnecessary to go into detailed discussion of his results. And there are works of such advanced and original thought that it is impossible to describe them in terms that would be understood by any except the most illustrious scientists. Such works as these are unfortunately in a vast minority, and there are very few scientific reports that have no material of direct value to the engineer and the industrial chemist or physicist.

It may be well to say a few words about the mechanical side of report writing, and in doing so it will be necessary to digress a bit to the methods of experimentation and collection of data. All data should be collected logically and neatly, and everything should be labelled, as what may be clear and obvious at one time may be quite obscure after a lapse of a few months. Again it is well to work up the data as far as possible as the work goes on, not only to check up on the validity of the observations, and to determine the completeness of the data required, but also to get the results in such shape that they can later be readily combined into a report, and no pains should be spared to constantly check up the results obtained in order to detect errors that might affect a long series of experiments. A complete photographic record should be made as the work progresses, or it may be necessary later to go to considerable extra work to obtain an illustration.



After all the necessary data have been collected, it is generally best to construct an outline so that the methods used, the results and the conclusions may be placed in logical order and, after this, all plots and other illustrations should be prepared and numbered in their proper sequence. The first draft of the report can then be written or dictated, and a dictaphone is a very convenient instrument for this purpose. Very few can write a report just as they wish it the first time, and like all other kinds of careful composition it requires a considerable amount of revision. It is of great value to have the aid and criticism of others in this stage, as the author loses his sense of perspective after working for a long time on one report.

In conclusion, the purpose of the report should be to carry some fact or theory so interestingly, so briefly, and so clearly that the busy world will stop to read it, and having read it will pause to think, for the ability to make men think in a new way should be the aim of every writer.



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